

COMBUSTOR DIFFUSER INTERACTION PROGRAM

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INTRODUCTION

Advances in gas turbine engine performance are achieved by using compressor systems with high stage loading and low part count, which result in high exit Mach numbers. The diffuser and combustor systems in such engines should be optimized to reduce system pressure loss and to maximize the engine thrust-to-weight ratio and minimize length. The state-of-the-art combustor-diffuser systems do not meet these requirements. Detailed understanding of the combustor-diffuser flow field interaction is required for designing advanced gas turbine engines.

An experimental study of the combustor-diffuser interaction (CDI) is being conducted to obtain data for the evaluation and improvement of analytical models applicable to a wide variety of diffuser designs. The CDI program consists of four technical phases:

- Phase I - Literature Search
- Phase II - Baseline Configuration
- Phase III - Parametric Configurations
- Phase IV - Performance Configurations

Phase II of the program is in progress.

OBJECTIVES

Objectives of the Phase II efforts are to:

- o Identify the mechanisms and the magnitude of aerodynamic losses in the prediffuser, dome, and shroud regions of an annular combustor-diffuser system
- o Determine the effects of geometric changes in the prediffuser, dome, and shroud wall on aerodynamic losses and loss mechanisms
- o Obtain a data base that can be used to assess advanced numerical aerodynamic computer models for predicting flowfield conditions in an annular combustor-diffuser system
- o Assess the ability of current analytical models to predict flowfield characteristics in annular combustor-diffuser systems, including pressure distributions
- o Upgrade the analytical models based on the experimental data for flowfield

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DESCRIPTION OF TEST CONDITIONS AND RIG

The test rig is a 60-degree sector of a full annular combustor-diffuser system whose cross-sectional details are shown in Figure 1. Air flow through the rig is established by connecting discharge ducts to vacuum lines. The airflow rate in each of the three lines is controlled to produce the desired flow split and a rig inlet Mach number of 0.35. The test rig performance evaluation is being made for 15 different flow conditions as shown in Table 1.

RESULTS

Water flow visualization tests were performed for all 15 flow conditions. The streamline patterns were photographed and compared with predicted results, which showed good agreement. A typical comparison is shown in Figure 2 for one of the test conditions. Subsequent to the flow visualization tests, detailed pressure and wall shear stress distribution measurements were made for these flow conditions. The instrumentation for pressure measurements are shown in Figure 3.

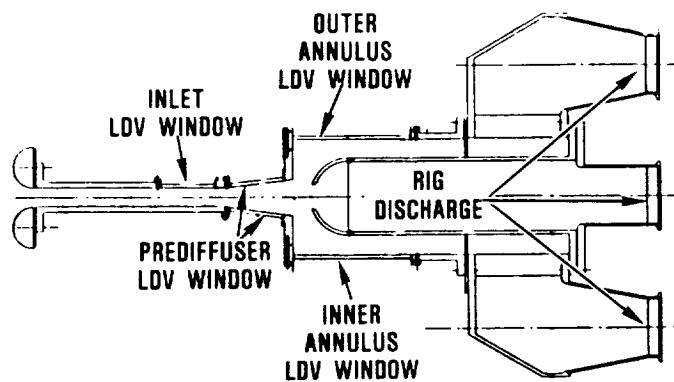
Shear stress distributions were measured only along the prediffuser walls (Figure 4). These data are being processed. The three-component LDV system (Figure 5) has been set up, and LDV measurements in the CDI test rig will be initiated to obtain detailed velocity field and turbulence quantities. Analytical model assessment and upgrade efforts will be performed in conjunction with the LDV measurements. Design efforts of the test rig for Phase III (Parametric Configurations) are underway. Figure 6 shows the configurations which will be evaluated during this phase.

TABLE 1. FLOW CONDITIONS USED DURING PHASE II TESTING

Percent Flow Split			
Test No.	Outer Annulus	Dome	Inner Annulus
1	32.9	20.0	47.1
2	40.0	20.0	40.0
3	48.0	20.0	32.0
4	55.0	20.0	25.0
5	60.0	20.0	20.0
6	26.8	35.0	38.2
7	32.5	35.0	32.5
8	39.0	35.0	20.3
9	44.7	35.0	20.3
10	48.8	35.0	16.2
11	20.6	50.0	29.4
12	25.0	50.0	25.0
13	30.0	50.0	20.0
14	34.4	50.0	15.6
15	37.5	50.0	12.5

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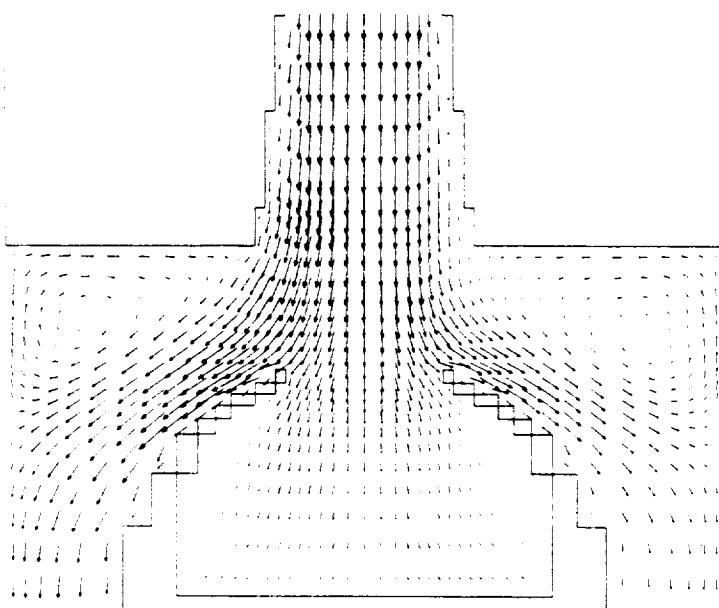
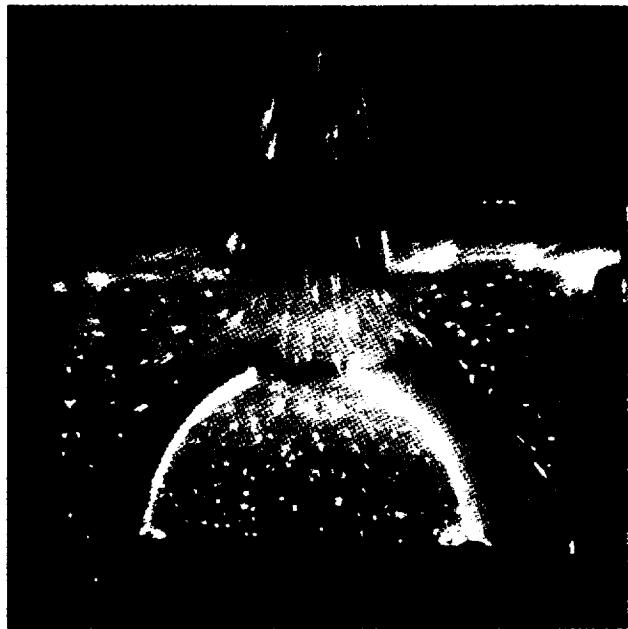
DESCRIPTION OF THE BASELINE TEST RIG.



INNER TO OUTER DIAMETER RATIO AT PREDIFFUSER INLET	0.92:1
PREDIFFUSER AREA RATIO	1.86:1
PREDIFFUSER LENGTH TO INLET HEIGHT RATIO	3.778:1
WALL DIVERGENCE ANGLE	6.5 DEGREES
RATIO OF DUMP GAP TO PREDIFFUSER EXIT HEIGHT	0.52
RATIO OF COMBUSTOR CHANNEL HEIGHT TO INLET DUCT HEIGHT	3.10
RATIO OF OUTER TO INNER ANNULUS AREA	1.5

FIGURE 1.

FLOW VISUALIZATION TEST RESULTS AND PREDICTED STREAMLINES.



TEST CONDITION NO. 6

FIGURE 2.

WALL STATIC, TOTAL PRESSURE RAKE, AND PRESSURE SURVEY LOCATIONS.

- ▲ STATIC PRESSURE PROBE (3 PROBES AT EACH LOCATION CIRCUMFERENTIALLY UNLESS NOTED) 132
- TOTAL PRESSURE RAKE-5 PROBES 4
- THERMOCOUPLE 4
- ✗ LOCATION OF PRESSURE SURVEY
 - INLET, 10 LOCATIONS
 - DIFFUSER EXIT, 20 LOCATIONS

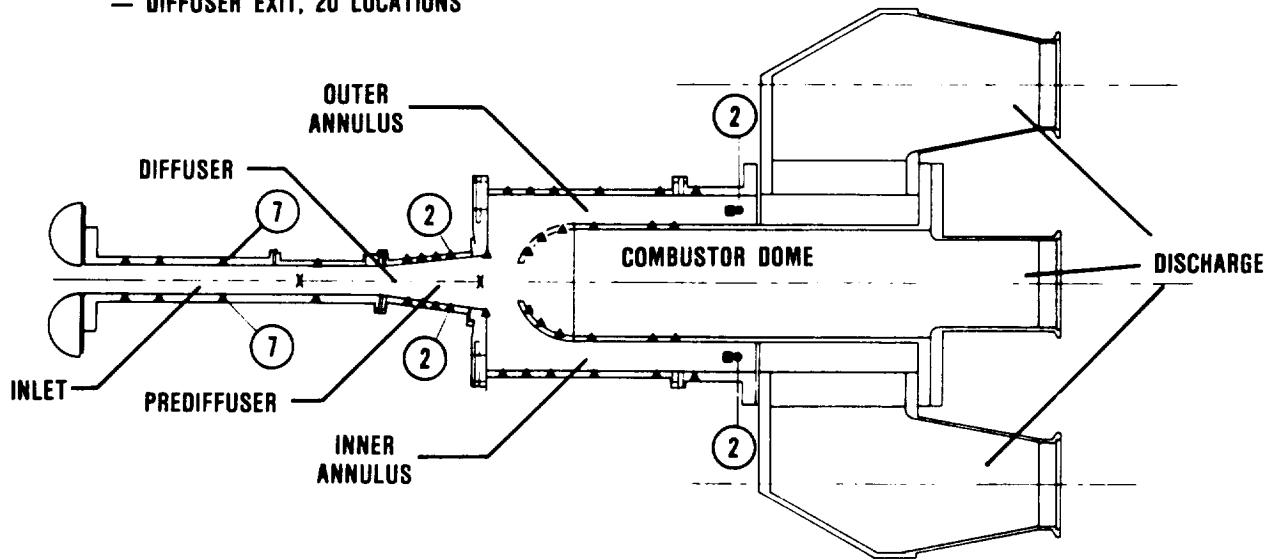


FIGURE 3.

**LOCATIONS OF FLUSH-MOUNTED HOT FILM SENSORS USED TO DIRECTLY MEASURE
WALL SHEAR-STRESSES IN THE PREDIFFUSER.**

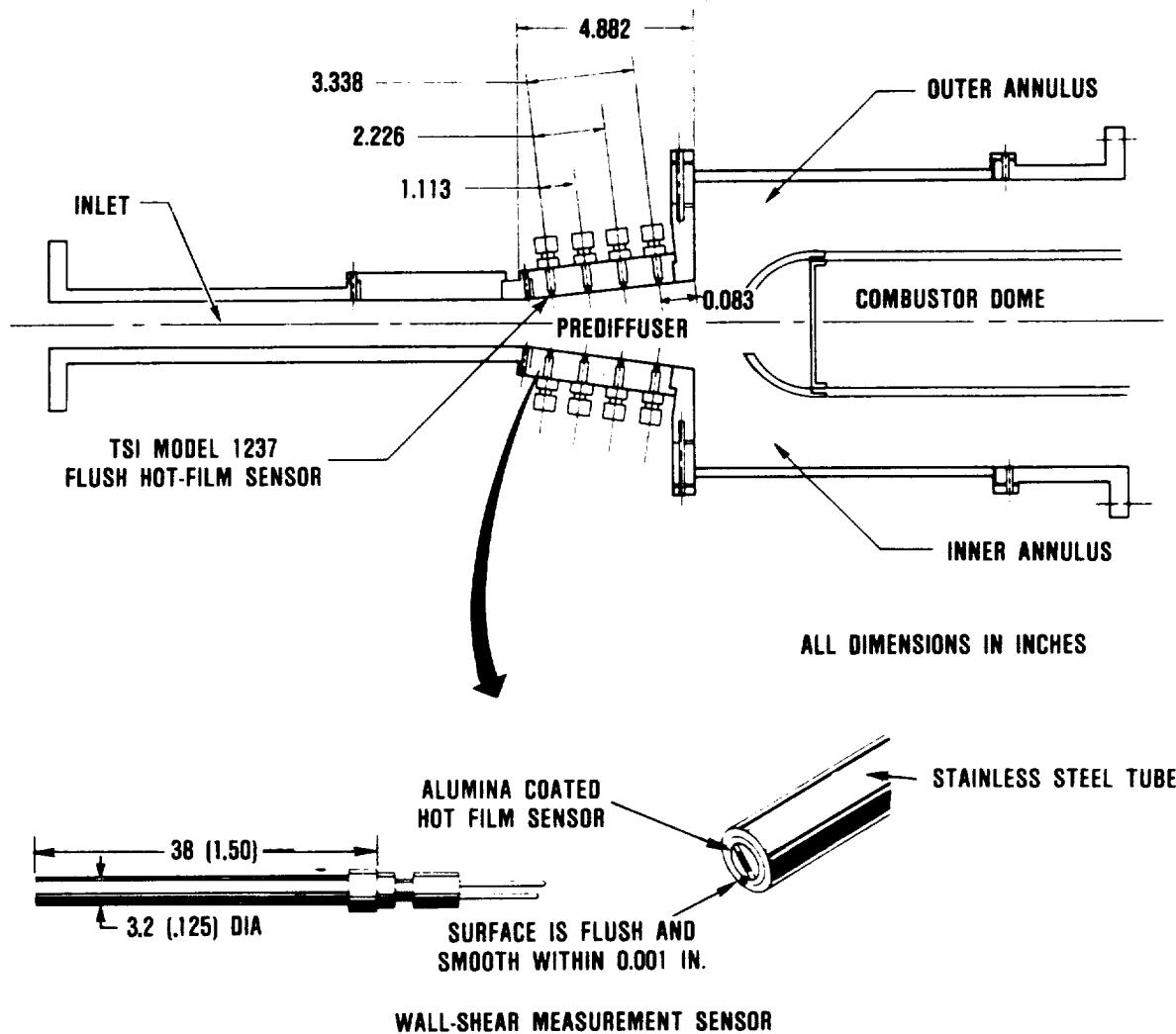
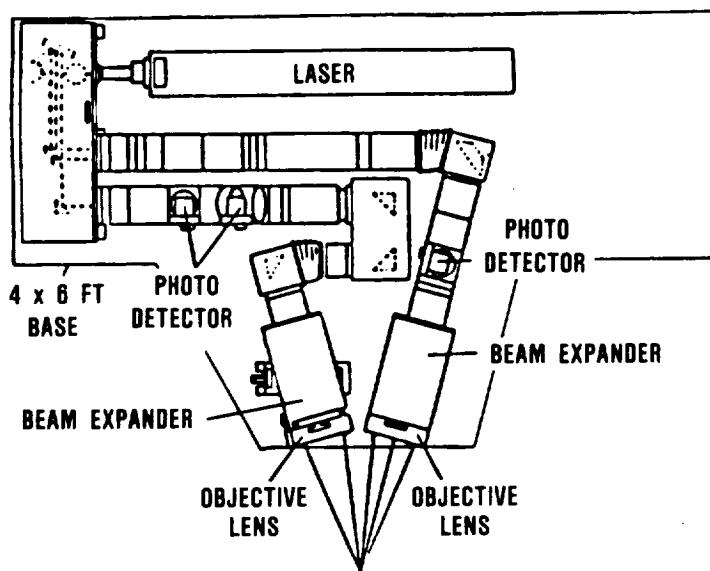


FIGURE 4.

SCHEMATIC OF THE THREE-COLOR, THREE-COMPONENT LDV SYSTEM.



- SYSTEM DESCRIPTION
- CHANNEL SEPARATION BY 3-COLOR
 - 3.75x BEAM EXPANSION
 - 450mm FOCAL LENGTH, 152mm OBJECTIVE LENSES
 - OFF-AXIS BACKSCATTER COLLECTION
 - DISPERSION PRISM COLOR SEPARATION
 - 150 M Hz BAND WITH SIGNAL CONDITIONING
 - 3-AXIS COMPUTER CONTROLLED TRAVERSING SYSTEM
 - PROBE VOLUME SIZE
 - DIAMETER = 0.6mm
 - LENGTH = 0.22mm
 - ESTIMATED ACCURACY ON VELOCITY COMPONENTS ABOUT 1 PERCENT WITH 30° SEPARATION ANGLE
 - VELOCITY RESOLUTION
 - 0.25% AT 40 M Hz OR 0.037 M/S AT 150 M/S

FIGURE 5.

SCHEMATICS OF PARAMETRIC CONFIGURATIONS FOR PHASE III TEST EVALUATION.

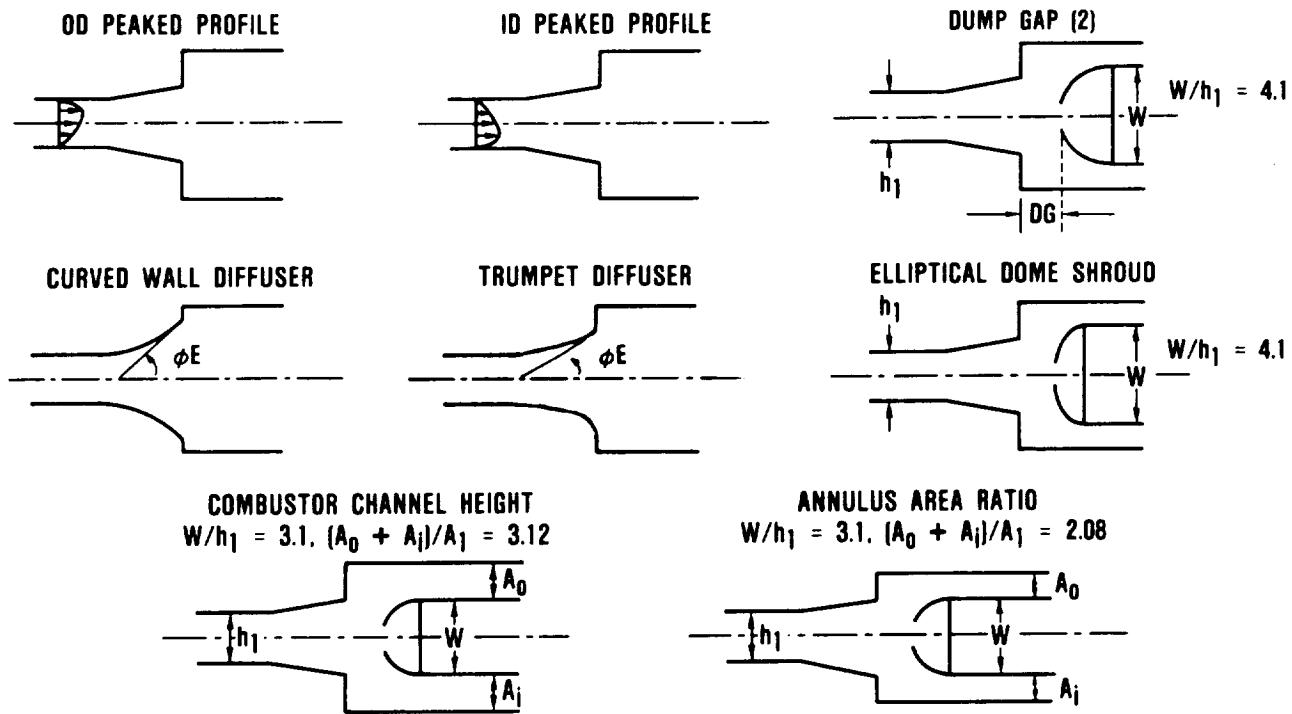


FIGURE 6.

